DAS KLIMA ALS WETTERGESAMTHEIT (CLIMATE AS TOTALITY OF THE WEATHER)

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(Translated from the German and summarized by Esek S. Nichols, Weather Bureau Office, San Jose, Calif., November, 1926)

The author shows that the usual method of presenting climatic data by means, averages, extremes, and sums of the various meteorological elements separately is untrue to nature; for these elements occur and act in combination only. For instance, the physiological processes of a plant at a given moment are not controlled by temperature, humidity, and precipitation separately, but by the combined action of these and the other meteorologicl elements; that is, by the weather. Therefore neither the single elements, nor still less their means, have any meaning for the plant. Further, it is quite clear that the same set of means of the principal climatic elements does not guarantee the same weather and, therefore, does not have the same meaning for the plant.

Quotations from several authors are given to show increasing dissatisfaction with present climatological methods. The opinion is expressed that it would be of great benefit to specialists along many lines, notably agronomists, botanists, physicians, and engineers, to receive climatic statements, not in the form of means, extremes, and frequencies of the separate meteological elements (or at least not only thus) but in the form of a group of weather types, with statement of their frequencies. Changes of types should be reported also; but types that occur so seldom that they may be termed "accidental" may, for most purposes, be omitted from reports.

Climate is conceived as a complex of actual natural phenomena—the weather sequence—and is likened to a living organism. The climate of a place is defined as "the totality of the weather observed there." Since the weather of each moment or of each day is extremely complicated and, in our higher latitude is, in addition, exceedingly variable, the expressing of climate in accordance with this definition is a problem whose solution requires a a method entirely different from, and greatly more complicated than, that now used. Evidently the observational material must be classified according to weather types determimed in gradations of values of the various meteorological elements. Such a system of classification is developed.

The primary unit chosen is the "weather case" or "weather hap," which is the weather that occurs at a place on any date (of 24 hours, night and day). The climate then consists of a succession of weather cases, which are to be classified into weather types. Of course, the greater the number of elements considered and the smaller their gradations the greater will be the number of types obtained. The following scheme is suggested:

I. Mean daily temperature; intervals, 5° C. (9° F.).

II. Change of mean temperature from that of preceding day; same intervals.

III. Daily range of temperature; same intervals.

IV. Mean daily relative humidity; intervals, 20 per cent.

V. Variations of cloudiness, night and day, separately.

VI. Precipitation, before or after noon separately.

VII. Wind direction, night and day, separately, to 16 points.

VIII. Force of the wind; calm, light, moderate, etc.

IX. Thunderstorm, with or without downpour of rain; distant thunderstorm.

X. Snow cover; depth and condition.

XI. Frost; dew; wet or dry ground in summer.

XII. Rime; ice storm; snow showers and rainfall in winter.

Then each day's weather is placed in a weather type determined by the limits (in accordance with the above scale) between which each of that day's elements falls. Record of the classification is made in cipher code on a card, one for each day. which is then filed with similar cards for other dates, forming a weather card index.

The code employed is very ingenious. By combining four letters, like a four-lettered word, the proper type can be designated, considering all the elements listed above. By using each of the 26 letters of the alphabet in both upper and lower cases and in both boldface and ordinary type, 104 characters are obtained, which present over 110,000,000 possible combinations using four characters at a time—far more than the number necessary to indicate all weather types possible anywhere in the world. It is very easy to arrange the cards for any period in groups according to similarity of types, and thus the frequencies of the latter can be counted. For various purposes the classification may be simplified by reducing the number of elements considered; or, on the other hand, other elements than those listed may be added or may be substituted for some of those on the list.

The general method proposed is illustrated by an accompanying diagram in five sections (not reproduced), which shows the frequencies of various weather types, using a greatly shortened list of elements, determined from records for 20 years at Pavlovsk during July, August, and September (a section of the diagram for each month separately), and from a 10-year record at Batavia, Java, during February and August (each month in a separate section). First, the relative frequencies of the type groups determined by daily mean temperature and daily mean relative humidity are proportional to the areas of squares, which are, in each section of the diagram, arranged according to increase of temperature upward and of humidity from left to right. Each square is divided into differently colored areas which are proportional to the frequencies of specified conditions of cloudiness within the respective temperature-humidity groups represented by the squares. Shading, by means of sets of parallel lines differently inclined further divides the temperature-humidity-cloudiness areas according to frequencies of various degrees of wind force. And the figures, 1, 2, 3, etc., are used to indicate frequencies of temperature range within specified limits. Each figure is entered upon any shaded colored area the number of times in 10 years the indicated daily temperature range occurs within the temperature-humidity-cloudiness-wind type specified by the particular area.

Then from this diagram we can easily obtain both the relative and absolute frequencies of the several types determined according to the five meteorological elements used, or according to any of the five desired; e. g., since we find in the July diagram for Pavlovsk the figure 2 entered twenty and one-half times in the light-blue unshaded area in the square for mean temperature 12½°–17½° C. and relative humidity 60–80 per cent, we understand (in accordance with explanatory notes) that 20½ July days in 10 years have mean temperature between 12½° and 17½° C., a temperature range of 5° to 10° C., mean relative humidity from 61 to 80 per cent, moderate winds, and

considerable cloudiness during the whole day. Certain signs are placed before or after the proper figures on the diagram to indicate the occurrence of precipitation, thunderstorm, and frost before or after noon, respectively, on certain type days. Thus an excellent idea of the weather that prevails (the climate) at Pavlovsk and Batavia during the months considered can be easily and quickly obtained. Seasonal changes and differences between climates can thus be strikingly shown by this method.

Reference is made to the publication in Russian in "Met. Wjestnik, 1925, No. 7," of an article by the author containing an exposition of the principles of the method, including details of the cipher code used in classification. Also, in a letter to Dr. Charles F. Brooks, the author refers to an address given in 1921 before the Congress of the Russian Society of Amateurs of Universal Knowledge, explaining the method in its primitive form; and to complete exposition before his observatory fellow members in 1924 and before the Russian Meteorological Committee of Geographical Society and Russian Geophysics Congress in April and May, 1925.

DISCUSSION

In his letter to Doctor Brooks, Mr. Federov refers to the group of papers in the MONTHLY WEATHER REVIEW for October, 1925, entitled "Papers on the Relation of the Atmosphere to Human Comfort," by C. F. Brooks and others; and states that the chief features underlying "my work are common with yours, and especially with E. S. Nichols." The outstanding common features of Fedorov's method and that considered in my paper, which is entitled "A Classification of Weather Types," are the recognition of the need of studying the combinations of the various meteorological elements (the weather), the classification of these combinations into a series of

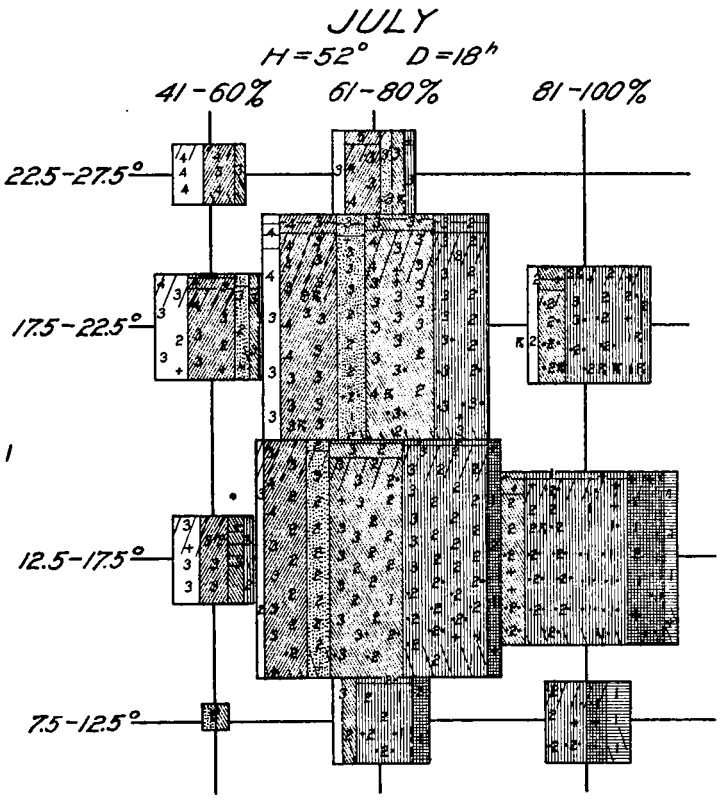

FIG. 1

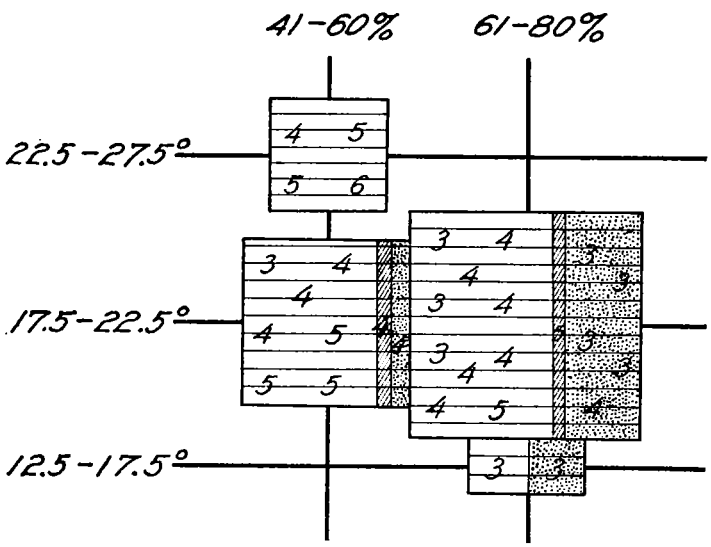

FIG. 2

Mean daily temperature: Indicated by figures at the left of the squares, in °C.
Mean daily relative humidity, per cent: Indicated by figures above the squares.
Cloudiness:

The whole day bright.

Cloudy at night; daytime clear.

The whole day faintly cloudy.

Clear at night, daytime cloudy.

Considerable cloudiness the whole day.

Heavy clouds the whole day.

Continuous rain the whole day.

Wind force: Light or calm.

Quiet at night, windy by day.

Moderate wind.

Strong wind.

Amplitude of temperature (daily range): Indicated by figures entered on the shaded areas:
Below 5° C., by the figure 1.
Between 5° and 10°, by the figure 2.
Between 10° and 15°, by the figure 3, etc.
Rain: Thunderstorm; ⊠. Frost: ⊔. These symbols placed before or after the figures, according as the occurrence was before or after noon.

weather types determined by gradations of values of the elements, determining the frequencies of the various types, and (for some purposes) the designation of types by a letter code. The main differences between the methods arise from choices of different units of weather to be classified.

Fedorov's use of the day's weather as a unit is a valuable method of analyzing weather records, and his diagram is an ingenious method of showing graphically much regarding the climate of a place. However, the daily unit is so complicated that the actual state of the atmosphere at any time is not shown in this way; for instance, the first steps in classification are according to daily *means* of temperature and relative humidity; and, while temperature range is given by the fifth step, no attempt is made to indicate variations in relative humid-

ity throughout the day, and therefore no idea regarding the actual temperature-humidity combinations can be obtained without making assumptions and computations.

Fedorov states in a footnote: "Perhaps it would be more natural to take the weather of a moment, but practically it is not satisfactory." However, this must be done; that it is practicable is shown in my previous paper and in the following article entitled "Frequencies of Weather Types at San Jose, Calif." Our unit is relatively simple, consisting of the instantaneous values of such elements as we may wish to consider. By analyzing observations taken at a regular time at a station we learn the frequencies of various types at that time of day for the month or other period desired. Conditions at other times of day are found by analyzing such other observations as may be desired and available.

Whether Federov's method or mine, or some other, shall be used in any particular study depends in part on the purpose in view; for instance, it appears that students of effects of weather upon human comfort and efficiency would prefer conditions in the morning, at noon, in the evening, etc., considered separately, by my method; while some botanical problems might be solved better by Fedorov's.

I have prepared diagrams according to Fedorov's scheme for San Jose, Calif., using data for the two months, January and July, 1926, separately. As might be expected, the number of types is intermediate between the numbers for Pavlovsk and Batavia. It is worthy of note, however, that an additional grade for daily range of temperature, above the highest used for Pavlovsk, was necessary; also that no thunder was recorded during either month considered, and that rain and frost occurred in the winter month only.

It is regretted that, on account of the impracticability of printing the necessary colors, none of the diagrams according to Fedorov's method is reproduced herewith.—*E. S. Nichols.*

Since the above summary and remarks were written Fedorov's paper has been published,[1] accompanied by diagrams in which shading is employed instead of colors for indicating cloudiness. While the diagrams are in this way not nearly so clear and striking as the originals, they are made suitable for reproduction in black and white. Figure 1, is a copy of the revised diagram for July at Pavlovsk, and Figure 2 has been prepared from San Jose data for July, 1926, according to the new method. It is suggested that if the reader will color Figures 1 and 2 in accordance with the original plan, he will obtain an adequate conception of Fedorov's scheme.—*E. S. Nichols.*

[1] "Das Wetter," 44 Jahrgang, Heft 6/7.

FREQUENCIES OF WEATHER TYPES AT SAN JOSE, CALIF.

By ESEK S. NICHOLS

[Weather Bureau, San Jose, Calif., November, 1926]

In accordance with my scale for classification of weather types (1), frequencies of various weather types at San Jose, Calif., have been determined from thrice-daily observations during the months of January, April, July, and October, for the five-year period, July, 1921, to April, 1926. Table 1, herewith, gives resulting data in tabular form; but conditions may be shown more clearly by a graphical method, which can be merely illustrated here, our space being limited. Classification begins with temperature and humidity, the importance of which is, therefore, emphasized.[1]

TABLE 1.—*Percentage frequencies of various weather types at San Jose, Calif., at thrice-daily observations during January, April, July, and October*

		H_{-2}			H_{-1}			H_0			H_{+1}			H_{+2}		
		W_0	W_1	W_2	W_0	W_1	W_2	W_0	W_1	W_2	W_0	W_1	W_2	W_0	W_1	W_2
January: 6:10 and 6:40 a. m. observations:																
T_{-1}	S_2				1			1			1			1	1	
	S_1													1		
	S_0							1	1		2	2	1	21	3	1
T_{-2}	S_2		1					2			2			31		
	S_1							1			1			7		
	S_0							1						16		
January (++): Noon observations:																
	S_2		1	1	1			1								
T_0	S_1					1		2	1		1					
	S_0	1						2	1		1					
T_{-1}	S_2	2	1		10	3		21	2	1	4					
	S_1				1	1		5	1	1	2					
	S_0		1		1			12	1		8	1		5	2	
T_{-2}	S_2															
	S_1															
	S_0													1		

[1] Temperature, relative humidity, wind velocity, and cloudiness are the meteorological elements used. Intervals are indicated on Figure No. 1 and in legends thereto; therefore the scale is not repeated here.

TABLE 1.—*Percentage frequencies of various weather types at San Jose, Calif., at thrice-daily observations during January, April, July, and October*—Continued

		H_{-2}			H_{-1}			H_0			H_{+1}			H_{+2}		
		W_0	W_1	W_2	W_0	W_1	W_2	W_0	W_1	W_2	W_0	W_1	W_2	W_0	W_1	W_2
January (+++): 4:40 p. m. observations:																
T_0	S_2	1			3			1								
	S_1				1			1			1					
	S_0				1	1		1			1					
T_{-1}	S_2	1			13	1		21	5		2	2				
	S_1				1			4	2		2			1		
	S_0				1	1		7	2		9	1	1	7		1
T_{-2}	S_2		1													
	S_1															
	S_0													1		
April (++): 6:10 and 6:40 a. m. obvations:																
	S_2										1			1		
T_0	S_1															
	S_0									1						
T_{-1}	S_2							5	1		8			16		
	S_1				1			1			1			7		
	S_0							4			15	1		29	3	
T_{-2}	S_2										4			1		
	S_1															
	S_0															
April (+++): Noon observations:																
T_{+2}	S_2		1		1											
	S_1															
	S_0															
T_{+1}	S_2	1	3		4											
	S_1															
	S_0		1		1											
T_0	S_2	1	2		11	8		11	4							
	S_1				3	2		3	4							
	S_0				1			7	4	1				1		
T_{-1}	S_2					4	1	1	2							
	S_1					1		1	1							
	S_0				1	1		6	1		3		1	1	1	
April (++): 4:40 p. m. observations:																
T_{+2}	S_2				1	1										
	S_1															
	S_0															